

MAINTENANCE MANUAL

9303

TRUE RMS RF LEVEL METER

RACAL-DANA

RACAL
The Electronics Group

PUBLICATION NUMBER TH 3174
ISSUE 4.7.84

9303

TRUE RMS RF LEVEL METER

RACAL-DANA

RACAL-DANA INSTRUMENTS INC.

4 Goodyear Street, PO Box C 19541, Irvine, Ca 92713, USA.
Telephone: (714) 859-8999. TWX: 910-595-1136, TLX: 678-341

RACAL-DANA INSTRUMENTS LTD.

Duke Street, Windsor, Berkshire SL4 1SB, United Kingdom
Telephone: Windsor (07535) 68101, TLX: 847013

RACAL-DANA INSTRUMENTS S.A.

18 Avenue Dutartre, 78150 Le Chesnay, France
Telephone: (3) 955-8888, TLX: 697 215

RACAL-DANA INSTRUMENTS GmbH

Hermannstrasse 29, D-6078 Neu Isenburg, Federal Republic of Germany
Telephone: 06102-2861/2, TLX: 412896

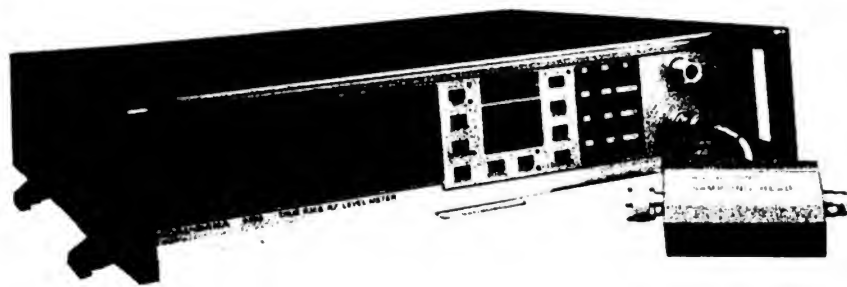
RACAL-DANA INSTRUMENTS ITALIA SRL

20161 Milano, Via Angeloni 8, Italy
Telephone: (02) 6459558/6468189 TLX: 315697

The logo consists of the word "RACAL" in a bold, sans-serif font. Each letter is contained within a thick, black rectangular border, giving it a three-dimensional or blocky appearance.

PUBLICATION DATE: NOVEMBER 1982

Copyright ©1982 by Racal-Dana Instruments Ltd. Printed in England. All rights reserved.
This book or parts thereof may not be reproduced in any form without written permission of the publishers.



True R.M.S R.F Level Meter 9303

TABLE OF CONTENTS

Section	Title	Page
1	TECHNICAL SPECIFICATION	1-1
1.1	Specification	1-1
2	GENERAL DESCRIPTION	2-1
2.1	Introduction	2-1
2.2	Measuring Head	2-1
2.3	Reduction of Display Jitter	2-2
2.4	Noise Cancellation	2-2
2.5	Measurement Principles	2-2
2.6	Storage of Front Panel Settings	2-3
2.7	GPIB Interface	2-3
2.8	Maintenance	2-3
3	PREPARATION FOR USE	3-1
3.1	Introduction	3-1
3.2	Power Supply	3-1
3.2.1	AC Voltage Range Setting	3-1
3.2.2.	Line Fuse	3-1
3.2.3	DC Fuse	3-2
3.2.4	Power Lead	3-2
3.3	Connection of Measuring Heads	3-2
3.4	Fitting the Fixed Rack Mounting Kit 11-1496	3-3
3.5	Removal and Replacement of the Covers	3-4
3.6	Preparation for Use With the GPIB	3-4
3.6.1	Interface Connector	3-4
3.6.2	Address Setting	3-5
4	OPERATING INSTRUCTIONS	4-1
4.1	Introduction	4-1
4.2	Description of Controls, Indicators and Connectors	4-1
4.2.2	Front Panel Items	4-1
4.2.3	Rear Panel Items	4-5
4.3	Switching On	4-8
4.4	Measuring Head Calibration	4-8
4.4.1	The FACTORY ECAL	4-8
4.4.1.2	Using the CALIBRATOR Sockets	4-9
4.4.1.3	Using an External Calibration Source	4-9
4.4.2	The USER ECAL	4-10
4.4.2.3	Using the CALIBRATOR Sockets	4-10
4.4.2.4	Using an External Calibration Source	4-11
4.4.2.5	USER ECAL Factor Enablement	4-11
4.5	Measuring Head Attachments	4-11
4.5.1	50 Ω Attenuators	4-11
4.5.2	Signal Amplifiers	4-12
4.5.3	High Impedance Probes	4-12
4.5.4	Low Impedance Probes	4-13

TABLE OF CONTENTS (Continued)

Section	Title	Page
4.6	Display of ECAL Factors	4-13
4.7	Frequency Response	4-13
4.8	Setting of Averaging Time	4-14
4.9	Continuous Averaging Mode	4-15
4.10	Ranging Mode Setting	4-15
4.11	Voltage Primary Measurement Function	4-16
4.12	Power Primary Measurement Function	4-16
4.13	Ratio Measurements	4-17
4.14	Percentage Difference Measurements	4-18
4.15	Null Measurements	4-19
4.16	dB Measurements	4-19
4.17	Analogue Display	4-20
4.18	Storage of Front Panel Settings	4-20
4.19	Special Functions	4-21
4.20	Error Codes	4-21
4.21	Control Via the GPIB	4-24
4.22	Remote/Local Changeover	4-24
4.22.1	Local to Remote Changeover	4-24
4.22.2	Remote to Local Changeover	4-24
4.22.3	Local Lockout	4-25
4.23	Command Codes for Addressed Mode Operation	4-25
4.24	Entry of Numerical Values	4-34
4.25	Output Message Format	4-35
4.26	Status Byte Format	4-36
4.27	Service Request (SRQ) Output	4-36
4.28	Logic Levels	4-36
5	PRINCIPLES OF OPERATION	5-1
5.1	Introduction	5-1
5.2	Principles of Operation	5-1
5.2.1	Functional Systems	5-1
5.2.2	The Sampling System	5-1
5.2.3	The Analogue Processing System	5-2
5.2.4	The Microprocessor System	5-2
5.2.4.3	Digital Signal Processing	5-3
5.2.4.4	Instrument Control	5-3
5.2.5	The Keyboard/Display System	5-3
5.2.6	The Calibrator System	5-4
5.2.7	The GPIB Interface	5-4
5.3	Technical Description	5-7
5.3.1	The Sampling System	5-7
5.3.1.2	10 Hz Triangular Waveform Generation	5-7
5.3.1.3	Voltage Controlled Oscillator	5-7
5.3.1.4	Sampling Pulse Generation	5-8
5.3.1.5	Sampling Bridge Operation	5-8
5.3.1.6	Pulse Amplification	5-8
5.3.1.7	Bias Control Circuit	5-9
5.3.2	Analogue Signal Processing System	5-9
5.3.2.2	Input Multiplexer	5-9
5.3.2.3	Switched Gain Amplifier	5-9
5.3.2.4	Second Sampler	5-10

TABLE OF CONTENTS (Continued)

Section	Title	Page
5.3.2.5	True RMS Detector	5-12
5.3.2.6	Output Sample and Hold	5-16
5.3.2.7	Auto-Zeroing	5-16
5.3.2.8	Prevention of Lock Up	5-17
5.3.3	The Microprocessor System	5-17
5.3.3.4	Analogue to Digital Conversion	5-18
5.3.3.5	Digital Data Input	5-19
5.3.3.6	Digital Data Processing	5-19
5.3.3.7	Serial Data Output to Display	5-19
5.3.3.8	Parallel Data Output to the GPIB Interface	5-19
5.3.3.9	Data Input from the GPIB Interface	5-19
5.3.3.10	Data Input from the Keyboard	5-20
5.3.3.11	Attenuator, Measuring Head and Calibrator Control	5-20
5.3.3.12	The Chip Select Circuit	5-21
5.3.3.13	Reset and Memory Supply Changeover Circuit	5-21
5.3.3.14	Test Switch Bank S30	5-22
5.3.4	The Keyboard/Display System	5-22
5.3.4.3	The Keyboard	5-22
5.3.4.4	The Liquid Crystal Display	5-22
5.3.4.5	The LED Indicators	5-23
5.3.5	The Calibrator System	5-23
5.3.5.2	The Internal Calibrator	5-23
5.3.5.3	The External Calibrator	5-24
5.3.6	The GPIB Interface	5-24
5.3.6.2	Address Setting and Recognition	5-24
5.3.6.3	Operation as a Listener	5-24
5.3.6.4	Operation as a Talker	5-25
5.3.6.5	Detection of the Serial Poll Disable Message	5-26
APPENDIX 1	Analysis of RMS Measuring Circuit	5-27
APPENDIX 2	Operation of Linearised Transconductance Multiplier	5-29
6	MAINTENANCE	6-1
6.1	Introduction	6-1
6.2	General Maintenance Information	6-1
6.2.1	Repair and Calibration of the Measuring Head	6-1
6.2.2	Battery Replacement	6-1
6.2.3	Special Functions for Maintenance Purposes	6-3
6.2.4	Test Switches	6-4
6.3	Fault Finding on Assemblies 19-1014 and 19-1017	6-4
6.3.1	Introduction	6-4
6.3.2	Assembly 19-1014	6-4
6.3.3	Assembly 19-1017	6-4
6.4	Signature Analysis	6-8
6.4.1	Preparation for Signature Analysis	6-8
6.4.2	Connection of the Signature Analyser	6-8
6.4.3	Analysis Procedure	6-8
6.5	Calibration Procedure	6-12
6.5.1	Introduction	6-12
6.5.2	Test Equipment Required	6-12
6.5.3	Temperature During Calibration	6-12
6.5.4	Signal Source Level Setting	6-12
6.5.5	Additional Measuring Head	6-12

TABLE OF CONTENTS (Continued)

Section	Title	Page
6.5.6	Setting Up the Power Supplies	6-14
6.5.7	Setting Up Assembly 19-1014	6-18
6.5.8	Setting the Measuring Head Bias Balance	6-18
6.5.9	Setting the Second Sampler Pulse Width	6-19
6.5.10	Setting the Internal Calibrator	6-19
6.5.11	Setting the External Calibrator	6-20
6.5.12	Setting the Upper Range Attenuators	6-21
6.5.13	Final Attenuator Setting	6-22
6.5.14	Checking Measuring Head Gain	6-23
6.5.15	Noise Checks	6-23
6.5.16	Linearity Adjustment	6-24
6.5.17	Accuracy Check	6-25
6.5.18	Frequency Response	6-27
6.5.19	VSWR Check	6-29
6.5.20	Insertion Loss	6-30
6.6	Dismantling and Reassembly	6-31
6.6.1	Introduction	6-31
6.6.2	Removal and Replacement of the Covers	6-31
6.6.3	Removal of Assemblies 19-1015 and 19-1016	6-31
6.6.4	Removal of the Front Panel	6-32
6.6.5	Removal of Assembly 19-1013	6-33
6.6.6	Replacement of the LCD	6-33
6.6.7	Calibrator Sockets	6-35
7	PARTS LIST AND CIRCUIT DIAGRAMS	
	Parts List: Front and Rear Panel Assemblies	Parts List 1
	Parts List: Measuring Head Assembly	Parts List 3
	Parts List: Keyboard and Display Assembly	Parts List 7
	Parts List: Processor Assembly	Parts List 9
	Parts List: Signal Converter Assembly	Parts List 15
	Parts List: Amplifier Assembly	Parts List 19
	Parts List: GPIB Assembly	Parts List 27
	Parts List: GPIB Connector Assembly	Parts List 29
	Internal Layout	Fig. 1
	Measuring Head Assembly: Component Layout	Fig. 2
	Circuit Diagram	Fig. 3
	Keyboard and Display Assembly: Component Layout	Fig. 4
	Circuit Diagram	Fig. 5
	Processor Assembly: Component Layout	Fig. 6
	Circuit Diagram	Fig. 7
	Signal Converter Assembly: Test Waveforms	7-1
	Component Layout	Fig. 8
	Circuit Diagram	Fig. 9
	Amplifier Assembly: Test Waveforms	7-3
	Component Layout	Fig. 10
	Circuit Diagram	Fig. 11
	GPIB Assembly: Component Layout	Fig. 12
	Circuit Diagram	Fig. 13
	GPIB Connector Assembly: Component Layout	Fig. 14
	Circuit Diagram	Fig. 15
	Interconnections	Fig. 16

LIST OF ILLUSTRATIONS

Figure	Title	Page
1.1	Input Waveform Crest Factor Limits	1-5
3.1	Fitting the Fixed Rack Mounting Kit	3-3
4.1	Front Panel Layout	4-7
4.2	Rear Panel Layout	4-7
5.1	Block Diagram	5-5
5.2	Idealised Waveforms: Sampling and Signal Processing	5-11
5.3	Feedback Loop Operation	5-13
5.4	Multiplier	5-14
5.5	Feedback Switching	5-15
5.6	Comparator Waveforms	5-16
5.7	Feedback Loop	5-27
5.8	Multiplier Operation	5-29
6.1	Input Socket (Viewed from the front)	6-16
6.2	Bias Balance Waveforms	6-19
6.3	Connections for VSWR Check	6-29
6.4	Fitting the Liquid Crystal Display	6-34
6.5	Calibrator Socket Mounting	6-35

LIST OF TABLES

Table	Title	Page
1.1	Technical Specification	1-1
3.1	GPIB Connector Pin Assignment	3-4
3.2	Address Switch Settings	3-6
4.1	Special Functions	4-22
4.2	Error Codes	4-23
4.3	Permitted Terminating Groups	4-25
4.4	Primary Measurements Function Commands	4-26
4.5	Ω Store Commands	4-26
4.6	Compute Function Commands	4-27
4.7	Range Commands	4-28
4.8	Head Selection Commands	4-28
4.9	Calibrator Control Commands	4-29
4.10	Control Setting Storage Commands	4-29
4.11	Control Setting Recall Commands	4-29
4.12	Calibrate Commands	4-30
4.13	Calibration Factor Commands	4-30
4.14	Interrupt Commands	4-31
4.15	Measurement Averaging Mode and Timing Selection Commands	4-32
4.16	Trigger Commands	4-33
4.17	Cancellation Commands	4-34
4.18	Numerical Input Format	4-34
4.19	Stored Value Units	4-35
4.20	Interface Output Message Format	4-35
4.21	Status Byte	4-36
6.1	Additional Special Functions	6-3
6.2	Test Switch Functions	6-4
6.3	Fault Finding Procedure Assembly 19-1014	6-5
6.4	Fault Finding Procedure Assembly 19-1017	6-6
6.5	System Signatures for Assembly 19-1014	6-9
6.6	System Signatures for Assembly 19-1017	6-10
6.7	Integrated Circuit Locations	6-11
6.8	Test Equipment Required for Calibration	6-13
6.9	Power Input Resistance	6-14
6.10	Integrated Circuit Locations	6-15
6.11	Voltage Regulation Test Limits	6-17
6.12	Switching Level	6-17
6.13	Linearity Check	6-25
6.14	Accuracy Check	6-26
6.15	Frequency Response Check Points	6-28
6.16	Frequency Response Check Points	6-28
6.17	VSWR Return Loss	6-30

1.1 SPECIFICATION

1.1.1 The published specification for the Racal-Dana True RMS RF Level Meter Model 9303 is given in Table 1.1.

TABLE 1.1

Technical Specification

OPERATIONAL MODES	
Measurement Functions:	<p>The 9303 measures true RMS voltage. This measurement may be displayed in voltage units, or converted, using a number of stored parameters, to provide a display of:</p> <ol style="list-style-type: none"> (1) The ratio of the measured voltage to a stored voltage level. This may be displayed as a numeric ratio, or in dB. (2) The difference between the measured voltage and a stored voltage level. (3) The difference as in (2) expressed as a percentage of the stored voltage level. (4) True power, computed as V^2/R, where R is a stored resistance value. (5) The ratio of the computed power to a stored power level. This may be displayed as a numeric ratio, or in dB. When the display is in the dB and the stored power level is 1 mW, the display units annunciator indicates dBm. (6) The difference between the computed power and a stored power level. (7) The difference as in (6) expressed as a percentage of the stored power level.

TABLE 1.1 (Continued)
Technical Specification

ELECTRICAL CHARACTERISTICS	
Frequency Range:	10 kHz to 2 GHz.
Voltage Range:	<p>30 μV to 3.162 V r.m.s. over the frequency range from 10 kHz to 700 MHz. 30 μV to 1 V r.m.s. over the frequency range from 700 MHz to 2 GHz. The instrument operates in nine voltage ranges having full scale readings of</p> <p style="text-align: center;"> 316.2 μV 1 mV 3.162 mV 10 mV 31.62 mV 100 mV 316.2 mV 1 V 3.162 V </p>
True Power Range:	<p>In a 50 Ω system: 20 pW to 200 mW over the frequency range from 10 kHz to 700 MHz. 20 pW to 20 mW over the frequency range from 700 MHz to 2 GHz.</p>
dBm Range:	<p>In a 50 Ω system: -77 dBm to +23 dBm.</p>
Input Impedance:	<p>With the measuring head terminated by the matched load supplied: 50 Ω nominal. Unterminated measuring head (at low frequencies): Approximately 100 kΩ in parallel with 20 pF.</p>
Input VSWR:	<p>With the measuring head terminated by the matched load supplied: Better than 1.1 up to 1 GHz. Better than 1.5 at 2 GHz.</p>

TABLE 1.1 (continued)

Technical Specification

ELECTRICAL CHARACTERISTICS (continued)

Measurement Accuracy:

The measurement accuracy, relative to the measuring head frequency response curve, for voltage measurements is given in the table which follows. The following points should be noted:

- (1) The quoted accuracy for the temperature ranges from 0°C to +18°C and from +28°C to +55°C will only be obtained if a USER ECAL factor, measured using the 9303 calibrator at a temperature within ±5°C of the operating temperature, is used.
- (2) The accuracy will be maintained for the quoted period from the date of FACTORY ECAL prior to despatch, or from the date of a FACTORY ECAL performed by the customer using the 9303 calibrator.

PERIOD	RANGE	+18°C to +28°C			0°C to 18°C and +28°C to +55°C		
		AT CAL. FREQ.	10kHz to 500 MHz	500 MHz to 2 GHz	AT CAL. FREQ.	10kHz to 500 MHz	500 MHz to 2 GHz
6 MONTHS	3.162 V and 316.2 µV	2.0 + 0.1	3.5 + 0.1	6.0 + 0.1	2.5 + 0.2	5.0 + 0.2	8.0 + 0.2
	1 mV to 1 V	1.0 + 0.1	2.5 + 0.1	5.0 + 0.1	1.5 + 0.2	4.0 + 0.2	7.0 + 0.2
12 MONTHS	3.162 V and 316.2 µV	2.25 + 0.1	3.75 + 0.1	6.25 + 0.1	2.75 + 0.2	5.25 + 0.2	8.25 + 0.2
	1 mV to 1 V	1.25 + 0.1	2.75 + 0.1	5.25 + 0.1	1.75 + 0.2	4.25 + 0.2	7.25 + 0.2
e = 20 x 10 ⁻⁶					e = 30 x 10 ⁻⁶		

VOLTAGE MEASUREMENT ACCURACY
(% OF READING + % OF RANGE)

The error (in voltage units) in the measurement obtained will not exceed the figure calculated from:

$$\text{Maximum Error} = \pm \left(\frac{M \times \%M}{100} + \frac{R \times \%R}{100} + \sqrt{M^2 + e^2} - M \right)$$

Where M is the measurement indication obtained, in volts
 %M is the % of measurement figure from the table
 R is the full scale value of the range in use, in volts
 %R is the % of range figure from the table
 e is the offset error from the table

Since e is added in RSS fashion it has greatest effect when the measured value is low.

Worked Example

Consider measurements being made at a temperature within the range from +18°C to +28°C, within six months of a FACTORY ECAL.

Suppose the measurement indication is 400 µV, using the 1 mV range, and the signal frequency is 500 kHz (calibration frequency).

From the table: %M = 1.0
 %R = 0.1
 e = 20 × 10⁻⁶

The error will not exceed

$$\begin{aligned} & \pm \left(\frac{400 \times 10^{-6} \times 1}{100} + \frac{1 \times 10^{-3} \times 0.1}{100} + \sqrt{16 \times 10^4 \times 10^{-12} + 4 \times 10^2 \times 10^{-12}} - 400 \times 10^{-6} \right) \\ & = \pm \left(4 \times 10^{-6} + 1 \times 10^{-6} + \sqrt{160400 \times 10^{-12}} - 400 \times 10^{-6} \right) \\ & = \pm \left(4 \times 10^{-6} + 1 \times 10^{-6} + 400.5 \times 10^{-6} - 400 \times 10^{-6} \right) \\ & = \pm 5.5 \mu\text{V} \end{aligned}$$

The maximum error in the power indication is obtained from the maximum voltage error as follows:

Voltage uncertainty is 394.5 µV to 405.5 µV
 In a 50 Ω system the equivalent power uncertainty,
 calculated from V²/R, is 3112 pW to 3288 pW

$$= 3200 \text{ pW} \pm 88 \text{ pW}$$

The maximum power error is therefore ± 0.088 nW.

TABLE 1.1 (Continued)
Technical Specification

ELECTRICAL CHARACTERISTICS (continued)	
Frequency Response:	For frequencies above 500 MHz a spot frequency correction factor, obtained from the frequency response curve on the measuring head, should be applied. This factor may be stored in the instrument to give automatic correction of the displayed measurement.
Insertion Loss:	A graph showing the variation of insertion loss with frequency is provided on the measuring head. The vertical scale of this graph is 0 to 3 dB in steps of 0.5 dB.
Crest Factor:	The range of crest factor of the measured waveform over which the specified accuracy will be maintained is shown in Fig. 1.1.

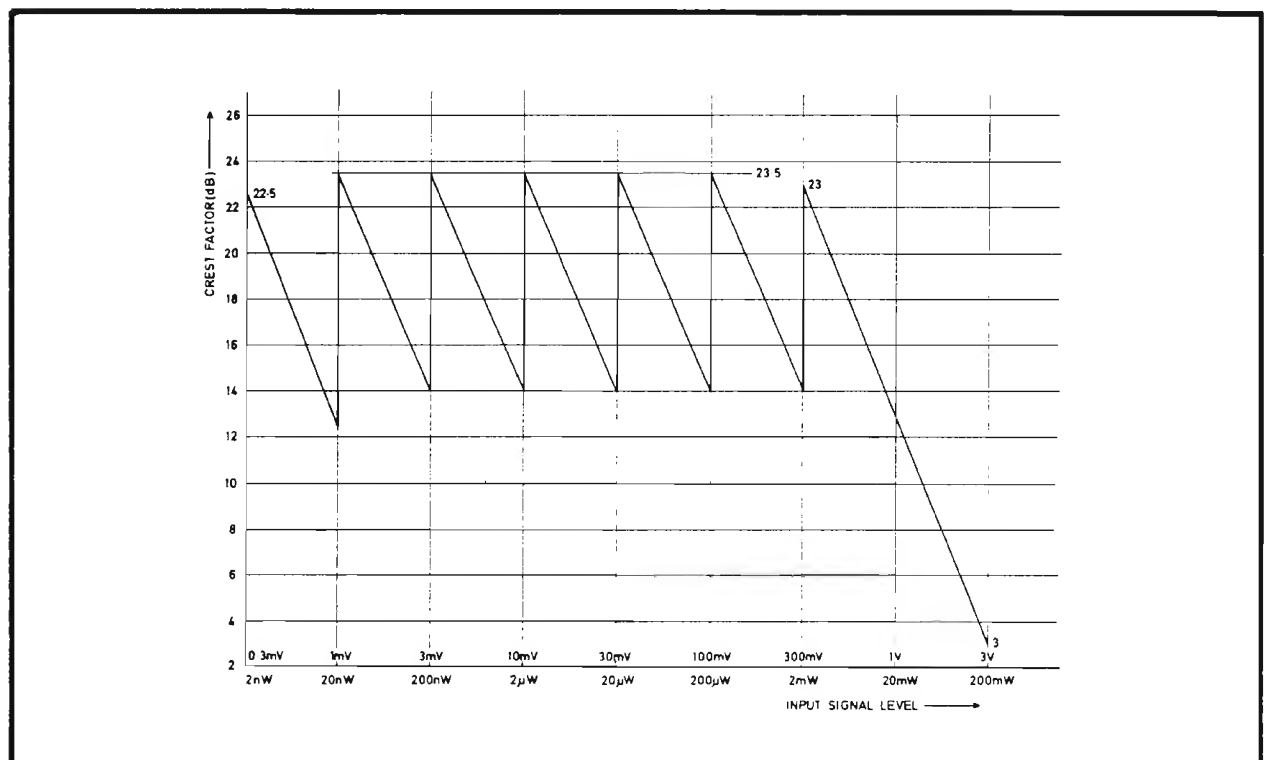


Fig. 1.1 Input Waveform Crest Factor Limits

TABLE 1.1 (continued)
Technical Specification

ELECTRICAL CHARACTERISTICS (continued)	
Maximum Input Level:	<p>The maximum input signal levels which can be tolerated without damage to the measuring head are:</p> <p>For the measuring head alone (in line or unterminated) 20 V peak-to-peak ± 100 V DC.</p> <p>For the measuring head terminated with the matched 50 Ω load, 7 V r.m.s. including any DC level present (1 W maximum).</p>
Averaging Time:	<p>The period between display updates, during which a number of measurements made are averaged, can be set in steps of 0.1 second between 0.1 second and 99.9 seconds (nominal). On switching on a value of 1 second is adopted automatically.</p>
Analogue Setting Time:	<p>A settling time of 3 seconds should be allowed after the application of the signal to be measured. This is independent of the averaging time in use.</p>
Input Connector:	<p>The measuring head is fitted with one male and one female Type N connector.</p>
MECHANICAL CHARACTERISTICS	
Instrument Dimensions:	<p>Height: 104 mm</p> <p>Width: 440 mm</p> <p>Depth: 403 mm</p>
Measuring Head Dimensions: (including connectors)	<p>Length: 125 mm</p> <p>Width: 45 mm</p> <p>Depth: 37 mm</p>
Instrument Weight:	<p>Approximately 6 kg.</p>

TABLE 1.1 (continued)
Technical Specification

POWER SUPPLIES	
Voltage:	A four range supply voltage selector is provided to accept 100 V, 115 V, 215 V or 230 V AC $\pm 10\%$.
Frequency:	45 to 440 Hz.
Power Consumption:	Approximately 50 VA.
ENVIRONMENTAL SPECIFICATION	
Operating Temperature:	0°C to +55°C.
Storage Temperature:	-40°C to +70°C. Corruption of the non-volatile memory contents may occur at temperatures below -20°C.
Humidity:	95% RH at +40°C.
Electromagnetic Compatibility:	The instrument is designed to conform with TS 1400, Class A.
ACCESSORIES PROVIDED	
Power Lead:	Part number 23-3227
Fuse for 90/127 V Operation:	Part number 23-0052
Operator's Handbook:	

TABLE 1.1 (Continued)
Technical Specification

OPTIONAL ACCESSORIES	
High Impedance Probe:	X10, complete with Type N to BNC adaptor. Part number 11-1512.
Low Capacitance Probes:	20 dB, complete with Type N to BNC adaptor. Input impedance 500 Ω . Part number 11-1573. 40 dB, complete with Type N to BNC adaptor. Input impedance 5 k Ω . Part number 11-1574.
19-inch Rack Mounting Kit:	Part number 11-1496.
Additional Measuring Head:	Measuring head complete with matched 50 Ω load. With 1 metre cable, part number 11-1478 With 2 metre cable, part number 11-1540
GPIB INTERFACE	
Function Subsets:	The interface operates in accordance with the following IEEE/IEC defined subsets: <div style="margin-left: 40px;"> Source handshake SH1 Acceptor handshake AH1 Talker T5 Extended talker TE0 Listener L4 Extended listener LE0 Service request SR1 Remote local RL1 Parallel poll PPO Device clear DC1 Device trigger DT1 Controller CO </div>
Interface type:	The interface uses open collector drivers, and is a type E1 interface as defined by IEEE standard 488.

TABLE 1.1 (Continued)
Technical Specification

GPIB INTERFACE (continued)	
Address Setting:	<p>Five rear panel mounted switches allow the selection of any one of 31 pairs of addresses. Each pair consists of a talk and a listen address. The talk and listen addresses in a pair are distinguished by the logic levels on data lines DIO 6 and DIO 7. These logic levels are decoded by the 9303 when in the listen state, or set by the 9303 when in the talk state without operator action.</p> <p>A sixth switch enables the 9303 to be put to the talk only mode.</p>
Measurement Modes:	<p>When addressed via the GPIB two measurement modes are available:</p> <ol style="list-style-type: none"> (1) Continuous mode: The instrument performs continuous measurement cycles. The last measurement taken is put onto the bus when the instrument is put into the talk state. (2) Single mode: The instrument performs a single measurement cycle in response to a trigger command (which may be addressed or the GET command). The measurement taken is put onto the bus when the instrument is put into the talk state. The instrument can be set to generate a service request (SRQ) when the measurement is complete. <p>When in the talk only mode the instrument performs continuous measurement cycles in accordance with the front panel control settings. The last measurement made is put onto the bus in response to a signal on the NRFD control line.</p>
Output Format:	The output data word consists of a string of twelve ASCII characters.
Optional Accessory:	Adaptor to convert to IEC 625-1 GPIB. Racal-Dana part number 23-3254

2.1 INTRODUCTION

2.1.1 The Racal-Dana RF Level Meter Model 9303 is a versatile, microprocessor controlled instrument. It will make measurements on signals having crest factors up to 15 and r.m.s. voltage levels between 30 μ V and 3.162 V. The instrument has an auto ranging facility, but provision for manual setting of the range is provided.

2.1.2 The full quoted accuracy is obtained over a frequency range from 10 kHz to 2 GHz. The instrument features an auto calibration facility. The calibration factors relating to the measuring heads are stored during the calibration procedure, and are used to adjust the displayed measurement without further operator action. A calibration signal source is provided for use should re-calibration of the measuring heads become necessary.

2.1.3 The instrument measures the true r.m.s. voltage of the applied signal. This may be displayed in voltage units, or converted to:

- (a) Indication of power, computed as V^2/R , where R is a resistance value stored in the instrument.
- (b) Indication of power relative to a power level which has been stored in the instrument. This may be displayed as a numeric ratio or in dB.
- (c) Indication of the percentage difference between the measured voltage or the computed power and a voltage or power level which has been stored in the instrument.
- (d) Indication of the difference between the measured voltage or the computed power and a voltage or power level which has been stored in the instrument.
- (e) Indication of the ratio of the measured voltage to a voltage level which has been stored in the instrument. This may be displayed as a numeric ratio or in dB.

2.1.4 The instrument features a large, four digit, liquid crystal display (LCD). Coarse and fine light dot displays form part of the display, and provide a pseudo-analogue form of indication. Units annunciators, operation limit warning indicators and calibration factor indicators are also incorporated.

2.2 MEASURING HEAD

2.2.1 Measurements are made via a measuring head, connected to the instrument by a cable. Measuring heads with 1 metre and 2 metre cables are available. The head is provided with a matched 50 Ω load for use when the instrument is to act as the system termination, but may be used to make in-line measurements in an accurate 50 Ω system. The head may also be used with a 50 Ω attenuator, or in conjunction with passive probes. The measuring

head calibration procedure allows the measurement of a calibration factor for the head alone, and the measurement of an additional calibration factor relating to any measuring head attachments in use. The calibration factors are stored separately, and can be separately enabled and disabled.

2.2.2 The measuring head used determines the measurement frequency response. Each head is provided with its own response curve, a correction factor from which can be stored in the instrument to give automatic correction of the displayed measurement at the selected spot frequency. The entry of a spot frequency calibration factor acts in addition to the calibration factors stored during the measuring head calibration procedures.

2.2.3 Two measuring heads may be connected to the instrument, one at the front and one at the rear. Correction factors for both heads may be stored, the appropriate factor being selected as the measurement function is switched between the heads.

2.3 REDUCTION OF DISPLAY JITTER

2.3.1 The instrument has a variable averaging time, which may be set by the operator to ensure minimum jitter of the measurement indication when measurements are made on waveforms of high crest factor. The period over which measurements are averaged may be varied in steps of 0.1 second between 0.1 second and 99.9 seconds (nominal).

2.3.2 The display updating rate is set by the averaging time in use. To avoid the necessity for unacceptably low updating rates, continuous averaging of the measurements can be introduced by means of a special function. In this mode the display is updated every 0.1 second, the new displayed value being formed by adding N% of the current displayed value to (100-N%) of the new measurement. The effect of this is similar to filtering successive measurements in a single pole RC filter. The value of N is related to the time constant of the effective filter, which can be set by the operator.

2.4 NOISE CANCELLATION

2.4.1 As part of the measuring head calibration procedure the signal due to noise is measured and stored. This figure is subtracted from subsequent measurements to provide noise cancellation.

2.5 MEASUREMENT PRINCIPLES

2.5.1 Samples are taken of the voltage across the strip line conductor in the measurement head. The sampler output is passed through a variable gain amplifier, to provide different operating ranges. A second sampling system is used to convert the amplifier output to a low frequency signal having a true r.m.s. value proportional to that of the measured signal. A direct voltage proportional to the r.m.s. value of this signal is obtained, using a linearised transconductance multiplier in a feedback loop.

- 2.5.2 To ensure that errors do not arise due to the first sampling frequency being a sub-harmonic of the measured signal frequency, a pseudo-random sampling waveform is generated from the output of a swept frequency oscillator.
- 2.5.3 The multiplier loop output is converted to digital form for processing by the microprocessor. The signal may be converted directly to a display segment drive signal, giving a display in voltage units, or processed, together with the contents of various internal stores, to provide power, percentage difference or difference displays.
- 2.6 **STORAGE OF FRONT PANEL SETTINGS**
- 2.6.1 Provision is made for the storage of up to 12 complete sets of front panel control settings, including the relevant calibration factors and computed function stores contents, in a non-volatile memory. Each setting is allocated a number, and can be retrieved by recalling that number.
- 2.7 **GPIB INTERFACE**
- 2.7.1 An internally mounted interface board permits the instrument to be controlled from and communicate with the IEEE 488 GPIB. The instrument may be used in the addressed mode or in the talk only mode. An adaptor to permit use with the IEC 625-1 GPIB is also available.
- 2.8 **MAINTENANCE**
- 2.8.1 It is recommended that customers should take advantage of the servicing and calibration service offered by Racal-Dana Instruments Ltd., and their agents.

3.1 INTRODUCTION

3.1.1 This section contains instructions concerning all tasks which must be performed before taking the 9303 into use for the first time, or when the instrument is used at a new location. It includes instructions for mounting the equipment in an equipment rack, if this is required, and for preparing the instrument for connection to a GPIB controlled system.

3.2 POWER SUPPLY

3.2.1 AC VOLTAGE RANGE SETTING

3.2.1.1 The supply voltage setting is varied by changing the position of a small printed circuit board, located under the fuse on the rear panel. The setting in use can be seen through the clear plastic fuse cover.

3.2.1.2 If it is necessary to change the voltage range proceed as follows:

- (a) Switch the instrument off, and remove the line power socket.
- (b) Slide the clear plastic fuse cover to the left, to expose the fuse.
- (c) Pull the lug marked FUSE PULL out and to the left. This will remove one end of the fuse from its holder. Remove the fuse.
- (d) Using a pair of snipe nosed pliers, pull out the voltage setting board from beneath the fuse holder.
- (e) Reinsert the board so that the required voltage range can be read the correct way up, when viewed from above, looking at the rear of the instrument.
- (f) Push the lug marked FUSE PULL back into position.
- (g) Insert the correct fuse for the range selected into the fuse holder.
- (h) Slide the clear plastic cover to the right until it is clear of the line power plug. Insert the line power socket.

3.2.2 LINE FUSE

3.2.2.1 Check that the line fuse rating is correct for the local AC supply voltage. The fuse is a $\frac{1}{4}$ in x $1\frac{1}{4}$ in glass cartridge, surge resisting type. The Racal-Dana part numbers for replacement fuses are:-

90 V to 127 V supply	500 mAT	23-0052
193 V to 253 V supply	250 mAT	23-0056

3.2.3 DC FUSE

- 3.2.3.1 Check that the DC fuse fitted to printed circuit board 19-1014 is serviceable, and of the correct rating. The fuse should be a 1.6 AT, surge resisting, $\frac{1}{4}$ in x $1\frac{1}{4}$ in glass cartridge type, Racal-Dana part number 23-0055. Instructions for the removal and replacement of the covers are given in paragraph 3.5.

3.2.4 POWER LEAD

- 3.2.4.1 The power lead must be fitted with a suitable connector in accordance with the standard colour code.

	<u>European</u>	<u>American</u>
Live	Brown	Black
Neutral	Blue	White
Earth(Ground)	Green/Yellow	Green

3.3 CONNECTION OF MEASURING HEADS

- 3.3.1 Connect the measuring head(s) to the appropriate INPUT socket(s). The instrument is supplied with a single measuring head, which bears the same serial number as the instrument, and is calibrated to permit this head to be used in either INPUT socket. If an additional measuring head is obtained, a FACTORY ECAL for this head must be performed in one INPUT socket in accordance with the instructions given in Section 4. This will destroy the calibration factor for that socket relating to the original head. The heads must then only be connected to the sockets calibrated for their use.
- 3.3.2 If the measuring head is connected to make through-line measurements, measurement accuracy may be adversely affected by the system VSWR.
- 3.3.3 If the measuring head is required to form a 50 Ω termination to a signal circuit it should be terminated with the matched 50 Ω load provided. If the signal is to be connected to the measuring head via a 50 Ω attenuator a USER ECAL factor for the measuring head and attenuator can be measured and stored. The procedure for this is given in Section 4. When enabled, this factor will compensate for the attenuator value.
- 3.3.4 The input impedance of the unterminated measuring head at low frequencies is approximately 100 k Ω in parallel with 20 pF, but the head may be used with passive probes to achieve other input impedances. If this is done a USER ECAL factor should be measured and stored and a calibration factor should be calculated and stored for use with the combination, as instructed in Section 4.
- 3.3.5 Customers requiring advice on the use of the 9303 in special systems should provide full details of the proposed application to Racal-Dana Instruments at the address given on the title page of this manual.

3.4 FITTING THE FIXED RACK MOUNTING KIT 11-1496

3.4.1 The kit contains a pair of mounting brackets and four screws. The method of fitting the kit is shown in Fig. 3.1. The fitting procedure is as follows:

- (a) Switch off the instrument and the AC supply. Remove the line power socket.
- (b) Stand the instrument upside down on a bench, and remove the two screws from each of the plastic mouldings at the rear corners of the instrument. Remove the mouldings.
- (c) Slide the bottom cover towards the rear of the instrument by about 1 inch, and lift the cover off.
- (d) Remove the bench feet from the bottom cover by removing the retaining screw from each foot. Replace the bottom cover.
- (e) Remove the side trim panels by sliding them to the rear of the instrument. Replace and secure the plastic mouldings removed in (b).
- (f) Remove the two screws securing the handle at one side of the instrument. Do not remove the handle.
- (g) Position a bracket from the kit at the side of the instrument, so that the two holes in a flange are positioned over the holes for the handle securing screws.
- (h) Secure the handle and bracket, using two of the countersunk headed screws from the kit.
- (j) Repeat (f) to (h) at the other side of the instrument.

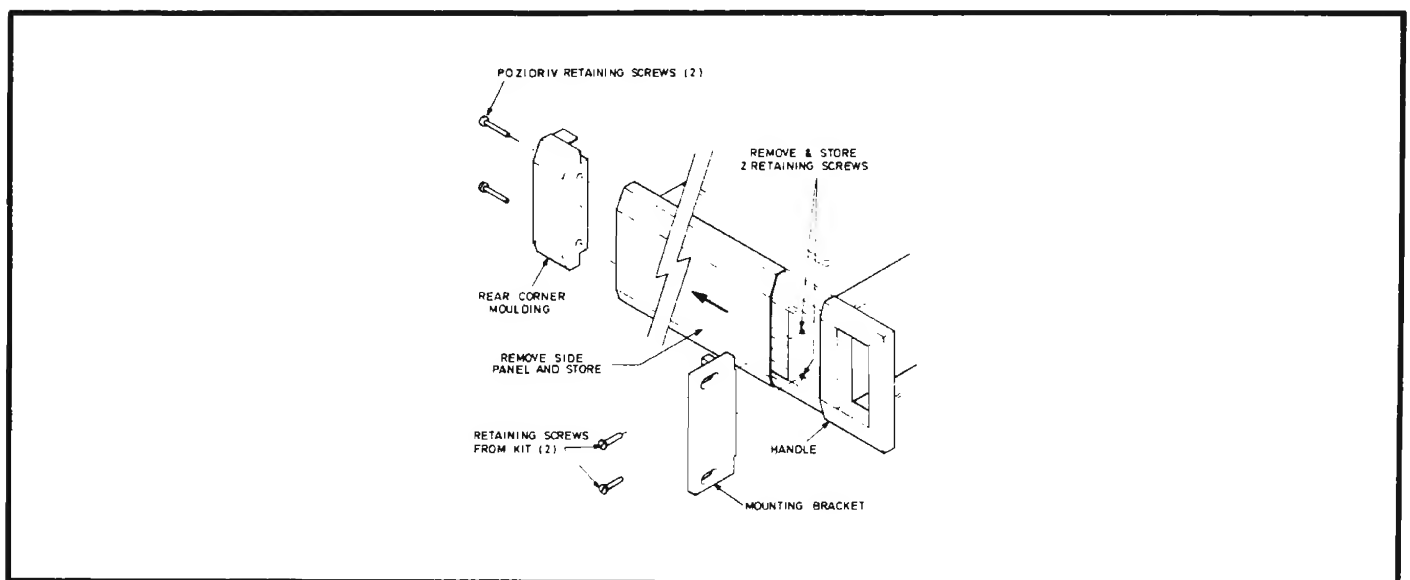


Fig. 3.1 Fitting the Fixed Rack Mounting Kit

3.5 REMOVAL AND REPLACEMENT OF THE COVERS

WARNING: DANGEROUS AC VOLTAGE LEVELS ARE EXPOSED WHEN THE COVERS ARE REMOVED WITH THE AC SUPPLY CONNECTED.

- 3.5.1
- (a) Switch off the instrument and the AC supply. Remove the line power socket.
 - (b) Stand the instrument on its front handles, and remove the two screws from each of the plastic mouldings at the rear corners of the instrument. Remove the mouldings.
 - (c) The covers can now be removed by sliding them towards the rear of the instrument. Note that the removal of the plastic mouldings also releases the side trim panels, which should either be removed or secured by replacement of the mouldings.
 - (d) The covers are replaced in the reverse manner. Note that the straight, unfolded edge of the cover fits to the front of the instrument, and locates in a groove in the rear face of the front panel. The rear edge of the cover is folded under, and locates in a groove in the rear panel.

3.6 PREPARATION FOR USE WITH THE GPIB

3.6.1 INTERFACE CONNECTOR

- 3.6.1.1 Connection to the GPIB is made via an IEEE 488 standard connector. The pin assignment is given in Table 3.1. An adaptor, Racal-Dana part number 23-3254, to convert the connector to the IEC 625-1 standard is available as an optional accessory.

TABLE 3.1
GPIB Connector Pin Assignment

Pin	Signal Line	Pin	Signal Line
1	DIO 1	13	DIO 5
2	DIO 2	14	DIO 6
3	DIO 3	15	DIO 7
4	DIO 4	16	DIO 8
5	EOI	17	REN
6	DAV	18	Gnd.(6)
7	NRFD	19	Gnd.(7)
8	NDAC	20	Gnd.(8)
9	IFC	21	Gnd.(9)
10	SRQ	22	Gnd.(10)
11	ATN	23	Gnd.(11)
12	SHIELD	24	Gnd.(5 and 17)

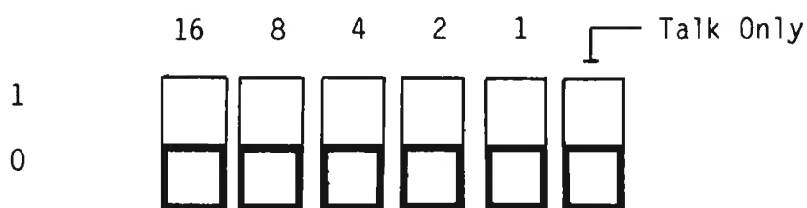
3.6.2 ADDRESS SETTING

3.6.2.1 The interface address is set on five rear panel mounted switches. The right hand switch, as viewed from the rear of the instrument, is for bit 1, the least significant address bit. The permitted address settings, in decimal and ASCII character form, are given in Table 3.2. The instrument is despatched with the address switches set to ASCII , (listen) and ASCII L (talk). The address set, in decimal format, can be displayed by pressing

/RECALL//SHIFT//LOCAL/.

3.6.2.2 The sixth switch, when put to the logic '1' position, puts the interface into the talk only mode. With the switch in this position the settings of the first five switches are irrelevant.

TABLE 3.2
Address Switch Settings



SWITCH SETTINGS						ADDRESS CODES		
						DECIMAL	ASCII LISTEN ADDRESS	ASCII TALK ADDRESS
16	8	4	2	1				
0	0	0	0	0	0	0	SP	@
0	0	0	0	1	1	1	!	A
0	0	0	1	0	2	2	"	B
0	0	0	1	1	3	3	#	C
0	0	1	0	0	4	4	\$	D
0	0	1	0	1	5	5	%	E
0	0	1	1	0	6	6	&	F
0	0	1	1	1	7	7	'	G
0	1	0	0	0	8	8	(H
0	1	0	0	1	9	9)	I
0	1	0	1	0	10	10	*	J
0	1	0	1	1	11	11	+	K
0	1	1	0	0	12	12	,	L
0	1	1	0	1	13	13	-	M
0	1	1	1	0	14	14	.	N
0	1	1	1	1	15	15	/	O
1	0	0	0	0	16	16	0	P
1	0	0	0	1	17	17	1	Q
1	0	0	1	0	18	18	2	R
1	0	0	1	1	19	19	3	S
1	0	1	0	0	20	20	4	T
1	0	1	0	1	21	21	5	U
1	0	1	1	0	22	22	6	V
1	0	1	1	1	23	23	7	W
1	1	0	0	0	24	24	8	X
1	1	0	0	1	25	25	9	Y
1	1	0	1	0	26	26	:	Z
1	1	0	1	1	27	27	:	[
1	1	1	0	0	28	28	<	\
1	1	1	0	1	29	29	=]
1	1	1	1	0	30	30	>	^

Instrument
despatched
with this
setting

4.1 INTRODUCTION

4.1.1 The first part of this section contains instructions for operating the 9303 using the front panel controls. This information is given in two forms. The purpose of each control is given in paragraph 4.2. This is followed by specific instructions on how to calibrate the instrument for use with different measuring head attachments, and how to set the instrument to make particular types of measurement.

4.1.2 Information regarding the control of the instrument using the GPIB is given, commencing at paragraph 4.21. It is essential that the operation of the instrument using the front panel controls is understood before operation using the GPIB is attempted.

4.2 DESCRIPTION OF CONTROLS, INDICATORS AND CONNECTORS

4.2.1 Each group of controls or connectors described is numbered to correspond with the indicators on Fig. 4.1 (front panel) or Fig. 4.2 (rear panel).

4.2.2 FRONT PANEL ITEMS

- ① Display: A custom-built, liquid crystal display is used. It incorporates the following indicators:
- (a) Four digit alpha-numeric display.
This display, with decimal point and sign indicator, is used primarily to indicate the value of the measured quantity. It may also be used to display the values held in the instrument's internal stores, or to indicate certain types of error.
 - (b) Units annunciators.
These indicate the units of the measurement being displayed.
 - (c) Compute function indicators.
These indicate when the measurement functions requiring computation by the microprocessor (ratio, % difference, difference (null) or relative power (dB)) are in use.
 - (d) CF indicator.
This provides warning that the calibration of the instrument has been changed by the introduction of operator set calibration factors.

(e) GPIB indicators
These indicate whether the instrument is under remote or local control, whether it is talking or listening and whether it is generating a service request.

(f) Analogue display
This is a two part, coarse and fine light dot display. The upper, coarse, section has ten dots, and indicates the measured value to within -0%, +10% of full scale. The lower, fine, section also has ten dots, representing sub divisions of the coarse section. The overall indication is therefore within -0% and +1% of full scale.
The coarse section of the display is enabled automatically when manual range selection is in use. The complete display may be enabled by pressing
/METER//METER/

② Range Control Keys: /MANUAL/
This key selects the auto-ranging and manual ranging modes on alternate operations. The appropriate indicator will light to show the mode in use. On switching from auto to manual no change of range will take place.

/STEP UP/ and /STEP DOWN/
These keys permit the next range above or below the one in use to be selected when in the manual ranging mode. If these keys are operated when the instrument is in the auto-ranging mode, the manual ranging mode will be selected and the appropriate change of range will occur.

③ METER Key:
This switches the analogue display on and off on successive operations.
The coarse part of the analogue display is switched on automatically when the manual ranging mode is selected. It will be switched off by the first operation of the METER key, subsequent operations of the key controlling the complete analogue display.

④ Primary Measuring Function Keys:
These keys allow the measured value to be displayed in voltage or power units. The appropriate indicator will light to show which function is in use.
The instrument measures true r.m.s. volts. When display in power units is demanded, the measured voltage is converted using the resistance value stored in the Ω store.

⑤ Computed Measuring Function Keys: These keys allow one of the four computed measuring functions to be selected. The appropriate indicator will light to show the function selected.

If the Voltage primary measuring function is in use the computations for all four functions will be performed in voltage units. If the Watts primary measuring function is in use the computations for the ratio, % difference and difference (null) functions will be performed in power units. The resistance value stored in the Ω store is used in the conversion from voltage to power units. The computation for the relative power (dB) function is always performed in voltage units.

The keys also act as the address keys for the computed function stores. The LED adjacent to the appropriate key will light when a stored value is recalled.

⑥ Calibration Key: The key is used without /SHIFT/ for the following purposes:

- (a) Successive operations of the key will enable and disable the calibration factor for the measuring head in use. The indicator will light when the calibration factor is enabled.
- (b) The sequence/RECALL//CAL FACTOR/ will result in the display showing the current value held in the calibration factor store.
- (c) The sequence/STORE//CAL FACTOR/ will store the number shown on the display in the calibration factor store. (The number displayed will have been set by means of the numeric keys).

The key is used with /STORE//SHIFT/ to measure and store a USER ECAL factor relating to any measuring head attachments which are used. This calibration factor is enabled, and disabled by successive operations of /SHIFT//EXT CAL/. The indicator will light when the USER ECAL factor is enabled. The indicator will flash, following switching on of the instrument, if the measuring head ECAL factor, stored in the non-volatile memory, is corrupted.

- ⑦ Front/Rear Selector Key: This selects the front or rear measuring head on successive operations. The appropriate indicator will light to show the head in use. Selection of the measuring head also selects, but does not necessarily enable, the appropriate head USER ECAL factor or any frequency calibration factor stored.
- ⑧ SHIFT Key: Pressing this key results in the next key pressed performing its shifted function. The shift operation affects the next key operation only, and cannot be continuously set.
- ⑨ STORE Key: This key is used, in conjunction with a store address key, to enter values in the instrument's internal stores. The instrument returns to the measurement mode when storage is completed. The indicator lights when the key is pressed, and is extinguished when storage is completed.
- ⑩ RECALL Key: This key is used, in conjunction with a store address key, to recall values from the instrument's internal stores. The use of the key stops the instrument measuring, so that the recalled information can be shown on the display, except in the case of recall of complete front panel settings. In this case the instrument returns to the measurement mode, with the recalled values set, as soon as the recall action is completed. The indicator lights when the key is pressed, and is extinguished when the instrument returns to the measurement mode, or when a new value is entered into store.
- ⑪ CONTINUE Key: Operation of this key returns the instrument to the measurement mode following the display of the contents of the instrument's internal stores.
- ⑫ Numeric Keypad: These keys, used without /SHIFT/, provide the means of setting, on the display, values to be entered in the instrument's internal stores. A CE key is included to allow clearance of entries containing errors.

The keys are used, with /SHIFT/, to add units annunciators to values to be stored, to address the Ω and response time (average) stores, to display the full scale deflection value of the measurement range in use and to select the special functions (SF). Pressing /SHIFT//LOCAL/ will return the instrument to local control from remote control via the GPIB except when the instrument is operating in the remote control with local lockout mode (RWLS).

⑬ CALIBRATOR Socket:

This socket provides a 0dBm in 50 Ω calibration signal for use when carrying out the measuring head calibration procedure. The output has a 500 kHz pulse waveform of approximately unity mark/space ratio. The output is normally disabled but may be enabled by means of special function commands entered via the front panel controls.

The rear panel CAL OUTPUT socket is wired in parallel with the CALIBRATOR socket. The correct output level is given when one socket only is loaded with 50 Ω .

⑭ INPUT Socket:

This socket accepts the front measuring head cable. The socket is connected to the measuring circuit when the FRONT indicator is lit.

⑮ LINE Switch and Indicator:

This switch controls the AC supply to the instrument power supply circuit. The indicator lights when the instrument is switched on.

4.2.3 REAR PANEL ITEMS

⑯ CAL OUTPUT Socket:

This socket provides a 0dBm in 50 Ω calibration signal for use when carrying out the measuring head calibration procedure. The output has a 500 kHz pulse waveform of approximately unity mark/space ratio. The output is normally disabled, but may be enabled by means of special function commands entered via the front panel controls.

The front panel CALIBRATOR socket is wired in parallel with the CAL OUTPUT socket. The correct output level is given when one socket only is loaded with 50 Ω .

- ①7 INPUT Socket: This socket accepts the rear measuring head cable. The socket is connected to the measuring circuit when the REAR indicator is lit.
- ①8 GPIB Socket: This socket is wired for direct connection to the IEEE 488 bus. An adaptor to permit the instrument to be used with the IEC 625-1 bus is available as an optional accessory.
- ①9 Address Switches: The five left hand switches allow one of 31 Listen/Talk address pairs to be selected. Putting a switch to the up position represents a logic '1'. The right hand switch represents the least significant bit (bit 1, on DIO 1).
- The sixth switch, when put to the up position, selects the talk only mode. The setting of the remaining address switches is then irrelevant.
- ②0 Supply Voltage Range Selector: This allows the selection of one of four line voltage ranges. The range selected can be read on the selecting plate through the clear plastic cover.
- ②1 Line Fuse: The fuse is a $\frac{1}{4}$ in x $1\frac{1}{4}$ in glass cartridge pattern, and should be of the anti-surge type.
- ②2 Line Power Plug: The power input plug incorporates a filter, and external supply filtering should be unnecessary.

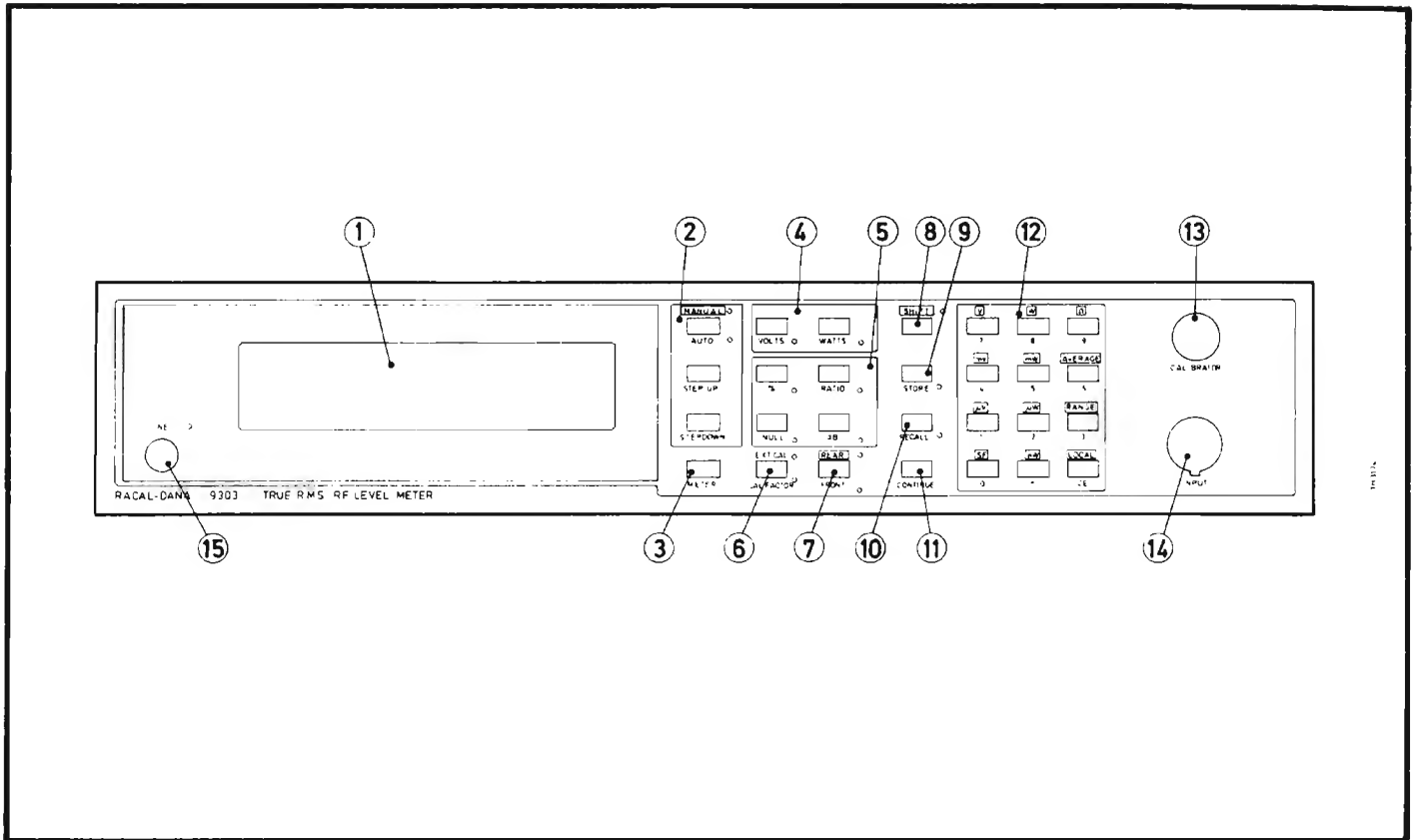


Fig. 4.1 Front Panel Layout

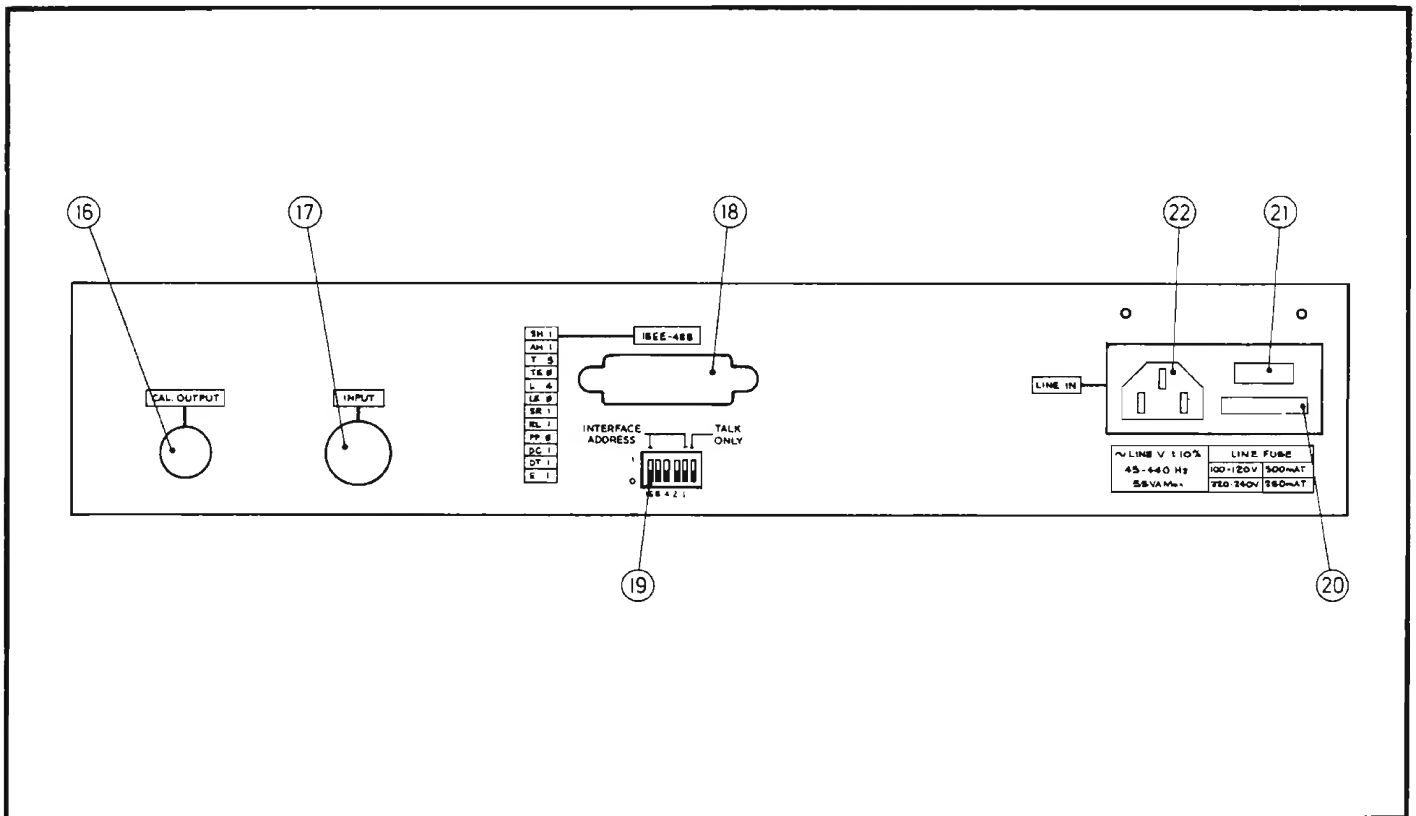


Fig. 4.2 Rear Panel Layout

4.3 SWITCHING ON

4.3.1 The equipment should be prepared for use in accordance with the instructions given in Section 3. If the instrument is being used for the first time, or at a new location, pay particular attention to the setting of the supply voltage range selector. Check that each measuring head is connected to the INPUT socket calibrated for its use.

4.3.2 Connect the instrument to the AC supply, and set the LINE switch to ON. Check that the LINE indicator lights. The front panel indicators will show:

- (a) AUTO mode
- (b) VOLTS measurement function
- (c) FRONT panel INPUT socket selected

The display will show ACAL, to indicate that an automatic internal calibration is being performed.

4.3.3 After approximately 10 seconds the ACAL indication on the display will be removed. Unless inhibited from doing so by the use of SPECIAL FUNCTION 20.2 (see paragraph 4.19) the instrument will carry out further internal calibrations automatically. When this occurs the ACAL indication will reappear in the display.

4.4 MEASURING HEAD CALIBRATION

4.4.1 THE FACTORY ECAL

4.4.1.1 The 9303 is supplied with a single measuring head, which bears the same serial number as the instrument. Before despatch the instrument is calibrated to permit this measuring head to be used in either INPUT socket. The resulting external calibration (FACTORY ECAL) factors are stored in the instrument's non-volatile memory, and the factor relating to the INPUT socket selected is enabled at all times when the instrument is in use. It will be necessary to re-calibrate one or both INPUT sockets if an additional or a replacement measuring head is obtained, or if the non-volatile memory contents become corrupted. This may be done with the measuring head connected to the measured signal circuit, or using the special CALIBRATOR outputs on the front and rear panels. For in situ calibration an accurate signal of 223.6 mV, true r.m.s., is required. The head should be terminated with the same load as will be used while measurements are made. If the 9303 CALIBRATOR outputs are to be used, the head should be terminated with the matched load supplied and connected to the appropriate CALIBRATOR socket.

NOTE: The front and rear CALIBRATOR outputs are wired in parallel. The sockets must NOT both be loaded at the same time at any point in the calibration procedure.

4.4.1.2 Using the CALIBRATOR Sockets

- 4.4.1.2.1 When the 9303 CALIBRATOR outputs are used the FACTORY ECAL sequence is started by pressing

/7//0//.//1//SHIFT//SF/.

An ECAL indication will appear in the display. The front measuring head will be calibrated and the FACTORY ECAL factor stored. The CALIBRATOR output will be automatically switched off, and the signal due to noise will be measured and stored. The ECAL indication will disappear when the procedure is complete.

- 4.4.1.2.2 The rear measuring head and CALIBRATOR output are selected by pressing

/REAR/.

The FRONT indicator will be extinguished and the REAR indicator will light. A second FACTORY ECAL cycle is started by pressing

/7//0//.//1//SHIFT//SF/.

- 4.4.1.2.3 If, during the calibration procedure, the ECAL factor measured is outside the range from 0.9 to 1.1, or the measured noise exceeds 300 μ V, the out of range value will not be stored.

4.4.1.3. Using an External Calibration Source

- 4.4.1.3.1 When using an external calibration source two calibration sequences are required for each measuring head, as the FACTORY ECAL factor and noise must be measured separately. The measurement of the FACTORY ECAL factor must be carried out first.

- 4.4.1.3.2 Connect the measuring head to the calibration source and switch the source on. Press

/7//0//.//1//SHIFT//SF/.

An ECAL indication will appear in the display and the front measuring head FACTORY ECAL factor will be measured and stored. The instrument will then carry out a noise measurement, and, since the calibration source will be switched on, will measure an excessive noise input.

- 4.4.1.3.3 Switch off the calibration source and initiate a second calibration sequence by pressing

/7//0//.//1//SHIFT//SF/.

The ECAL indication will reappear and a second measurement of FACTORY ECAL factor and noise will be made. Since the calibration source is switched off the FACTORY ECAL factor measured will be out of range, and the value measured during the previous calibration cycle will not be over-written.

The instrument will then measure and store the noise value. Once satisfactory calibration has been achieved the instrument will return to the measurement mode automatically.

- 4.4.1.3.4 The rear measuring head is calibrated by pressing

/REAR/

and repeating the procedure of paragraphs 4.4.1.3.2 and 4.4.1.3.3.

4.4.2 THE USER ECAL

- 4.4.2.1 The FACTORY ECAL factor is measured and stored under conditions such that measurements of the specified accuracy will be obtained in a normal working environment over the temperature range from 18°C to 28°C. If the 9303 is to be used in a special environment where this calibration is likely to be invalidated, e.g. at high temperature, an additional USER ECAL factor, for use in that environment only, can be measured and stored. The USER ECAL factor can be enabled and disabled as required, so that the FACTORY ECAL of the instrument for use in a normal environment is not affected.

- 4.4.2.2 The measurement of the USER ECAL factor may be made with the measuring head connected to the measured signal circuit, or using the special CALIBRATOR outputs on the front and rear panels. For in situ calibration an accurate signal of 223.6 mV, true r.m.s., is required. The head should be terminated with the same load as will be used while measurements are made. If the 9303 CALIBRATOR outputs are to be used the head should be terminated with the matched load supplied and connected to the appropriate CALIBRATOR socket.

NOTE: The front and rear CALIBRATOR outputs are wired in parallel. The sockets must NOT both be loaded at the same time at any point in the calibration procedure.

4.4.2.3 Using the CALIBRATOR Sockets

- 4.4.2.3.1 When the 9303 CALIBRATOR sockets are used, select FRONT or REAR as appropriate, and press

/STORE//SHIFT//EXT CAL/.

An ECAL indication will appear in the display. A USER ECAL factor for use in the environment in which the procedure is carried out will be measured and stored. The CALIBRATOR output will be automatically switched off and the signal due to noise will be measured and stored. The ECAL indication will disappear and the instrument will return to the measurement mode when measurement and storage are complete. Enable the USER ECAL factor, when required, as instructed in paragraph 4.4.2.5.

4.4.2.4 Using an External Calibration Source

4.4.2.4.1 When using an external calibrating source two calibration sequences are required for each head, as the USER ECAL factor and the noise must be measured separately. The measurement of the USER ECAL factor must be carried out first.

4.4.2.4.2 Connect the measuring head to the calibration source, select FRONT or REAR as appropriate and switch the source on. Press

/STORE//SHIFT//EXT CAL/.

An ECAL indication will appear in the display and a USER ECAL factor will be measured and stored. The instrument will then carry out a noise measurement, and, since the calibration source is switched on, will indicate excessive noise by means of a flashing Er 15.

4.4.2.4.3 Switch off the calibration source and initiate a second calibration cycle by pressing

/STORE//SHIFT//EXT CAL/.

The ECAL indication will re-appear and a second measurement of USER ECAL factor and noise will be made. Since the calibration source is switched off the USER ECAL measured will be out of range. The value measured on the previous calibration cycle will not be over-written, but at the end of the second cycle the ECAL indication will be replaced by a flashing Er 14. The instrument is returned to the measurement mode by pressing

/CONTINUE/.

Enable the USER ECAL factor, when required, as instructed in paragraph 4.4.2.5.

4.4.2.4.4 If at any time both the USER ECAL factor and the noise measurement are out of range, an Er 16 indication will appear instead of Er 14 or Er 15.

4.4.2.5 USER ECAL Factor Enablement

4.4.2.5.1 The USER ECAL factor is enabled and disabled by successive operations of

/SHIFT//EXT CAL/.

The EXT CAL indicator lights and a CF indicator appears in the display when the factor is enabled.

4.5 **MEASURING HEAD ATTACHMENTS**

4.5.1 50 Ω ATTENUATORS

4.5.1.1 The calibration of the 9303 may be modified to take account of 50 Ω attenuators attached to the measuring head. The attenuator should be attached to the measuring head and the head terminated with the matched 50 Ω termination supplied. A USER ECAL factor and a noise factor are then measured, stored and enabled using the procedures given in paragraph 4.4.2. The maximum value of attenuation for which a USER ECAL factor can be stored is 43 dB.

4.5.2 SIGNAL AMPLIFIERS

The calibration of the 9303 may be modified to take account of signal amplifiers used in conjunction with the measuring head. The head should be terminated with the matched 50 Ω load and connected to measure the amplifier output. The amplifier input should be connected to the appropriate CALIBRATOR output using a suitable coaxial connector. A USER ECAL factor and a noise factor are then measured, stored and enabled using the procedures given in paragraph 4.4.2. The maximum amplifier gain for which a USER ECAL factor can be stored is 10 dB.

4.5.3 HIGH IMPEDANCE PROBES

4.5.3.1 The calibration may be modified to take account of passive high impedance probes, such as the Racal-Dana model 11-1512, when these are attached to the measuring head. The following procedure should be followed:

- (a) Fit the probe to the measuring head using a BNC to Type N adaptor. Remove the matched 50 Ω termination from the measuring head.
- (b) Select /FRONT/ or /REAR/ as appropriate and connect the probe tip to the CALIBRATOR socket.

- (c) Press /AUTO//VOLTS//3//0//.//1//SHIFT//SF/.

This will turn on the calibration source.

- (d) Adjust the probe trimmer to obtain the maximum possible reading on the display.

- (e) Press /STORE//dB//dB/.

This will store the reading obtained in (d) in the dB store. The dB computed measuring function will be selected, as indicated by the dB indicator, and the display will indicate 0 dB.

- (f) Adjust the probe trimmer to obtain a reading of -1.2 dB \pm 0.1 dB.

- (g) Press /3//0//.//0//SHIFT//SF/.

This will turn off the calibration source.

- (h) Press /STORE//SHIFT//EXT CAL/.

This will measure and store a USER ECAL factor for the probe. The value is stored separately from the FACTORY ECAL factor for the measuring head, and can be disabled and enabled by means of successive operations of /SHIFT//EXT CAL/. This permits the probe to be detached, if required, without the need to re-calibrate when it is re-attached. When the USER ECAL factor is enabled the EXT CAL indicator lights and a CF indication appears in the display.

(j) Press/0//./5//STORE//CAL FACTOR//CAL FACTOR/.

This will store and enable a calibration factor which compensates for the fact that the CALIBRATION socket was not correctly matched during the USER ECAL measurement cycle. When storage is complete the instrument will be returned to the measurement mode with the calibration factor enabled and the probe ready for use. The calibration factor may be disabled and enabled by successive operations of

/CAL FACTOR/.

When the calibration factor is enabled the CAL FACTOR indicator will light.

4.5.4 LOW IMPEDANCE PROBES

4.5.4.1 If a low impedance probe, e.g. Racal-Dana 11-1573 or 11-1574, is used, the calibration procedure given in paragraph 4.5.3.1 should be modified as follows:

- (a) The measuring head must be terminated with the matched 50 Ω load.
- (b) For probes not fitted with trimmers steps (c) to (g) are omitted.
- (c) The calibration factor stored in step (j) should be calculated from

$$\text{Calibration Factor} = \frac{50 + R_p}{2R_p}$$

where R_p is the input impedance of the probe/measuring head combination.

4.6 DISPLAY OF ECAL FACTORS

4.6.1 The FACTORY ECAL and USER ECAL factors stored may be displayed by using SPECIAL FUNCTION 40.1 to 40.4 (see paragraph 4.19).

4.7 FREQUENCY RESPONSE

4.7.1 When making high frequency measurements a calibration factor may be entered and stored to take account of the frequency response of the measuring head. Each measuring head is provided with a frequency response curve from which an appropriate calibration factor can be read. If a probe is in use, the calibration factor calculated as instructed in paragraph 4.5.3 should be multiplied by the factor read from the measuring head response curve and the product entered in the CAL FACTOR store.

4.7.2 The calibration factor stored can be displayed by selecting

/FRONT/ or /REAR/

as required, and pressing

/RECALL//CAL FACTOR/.

The RECALL and CAL FACTOR indicators will light as the keys are pressed to indicate that a stored value is being displayed. If no change to the displayed calibration factor is required press

/CONTINUE/.

The RECALL and CAL FACTOR indicators will be extinguished and the instrument will return to the measurement mode. If the factor is to be changed, enter the new factor using the numeric keys. The RECALL and CAL FACTOR indicators will be extinguished when the first numeric key is pressed. When the required factor is correctly displayed, press

/STORE//CAL FACTOR/.

The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the factor entered is complete.

4.7.3 At any time up to the point where

/CAL FACTOR/

is pressed, the procedure can be aborted by pressing

/CONTINUE/.

The instrument will return to the measurement mode with the calibration factor unchanged.

4.7.4 The calibration factor is enabled and disabled by successive operation of

/CAL FACTOR/.

When enabled, the CAL FACTOR indicator will light and a CF indication will appear in the display.

4.8 SETTING OF AVERAGING TIME

4.8.1 When the equipment is first switched on the averaging time, which sets the display updating rate, is set to 1 second. This can be reset to provide a higher updating rate, or to give a lower updating rate with less jitter. The range of averaging times is from 0.1 second to 99.9 seconds in steps of 0.1 second. A settling time of 3 seconds should be allowed after the application of the signal to be measured irrespective of the averaging time in use.

4.8.2 The averaging time set can be displayed by pressing

/RECALL//SHIFT//AVERAGE/.

The RECALL indicator will light to indicate that a stored value is being displayed. If no change to the averaging time is required, press

/CONTINUE/.

The RECALL indicator will be extinguished and the instrument will return to the measurement mode. If the averaging time is to be reset, set the required value on the display, using the numeric keys. The RECALL indicator will be extinguished when the first numeric key is pressed. When the required averaging time is correctly set, press

/STORE//SHIFT//AVERAGE/.

The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

4.8.3 At any time up to the point where

/AVERAGE/

is pressed, the procedure can be aborted by pressing

/CONTINUE/.

The instrument will return to the measurement mode with the averaging time unchanged.

4.9 CONTINUOUS AVERAGING MODE

4.9.1 The use of this mode avoids the low display updating rates which are caused by the use of long averaging times. The display is updated every 0.1 second to a value obtained partly from the current displayed value and partly from the new measured value. The overall effect is similar to that which would be obtained if successive measured values were filtered in a single pole RC filter.

4.9.2 The continuous averaging mode is enabled and disabled using SPECIAL FUNCTIONS 50.1 and 50.0 (see paragraph 4.19). The time constant of the effective filter will be the value set in the AVERAGE store. This value may be viewed, and, if required, changed, using the procedure given in paragraphs 4.8.2 and 4.8.3.

4.9.3 The mode is automatically disabled during any measurement cycle in which the current displayed value and the new measured value differ by more than 5%. This results in a rapid change of the displayed value in response to large step changes of input level.

4.10 RANGING MODE SETTING

4.10.1 On switching on, the instrument will be set to the auto-ranging mode. To put the instrument into the manual ranging mode without changing the range in use, press the AUTO/MANUAL key. This key selects manual ranging and auto-ranging on successive operations. The indicator for the mode in use will light. The instrument may be switched from the auto-ranging mode to the manual ranging mode, accompanied by a change to an adjacent range, by means of the STEP UP or STEP DOWN key. When manual ranging is selected an analogue indication of the measured signal as a fraction of full scale appears in the display.

- 4.10.2 When in the manual ranging mode the range in use may be changed by pressing

/STEP UP/ or /STEP DOWN/.

The full scale value for the range in use can be displayed by pressing

/RECALL//SHIFT//RANGE/.

The RECALL indicator will light when the key is pressed. To return the instrument to the measurement mode, press

/CONTINUE/.

- 4.10.3 If the input signal is outside the limits of 10% and 110% of full scale of the range in use, the display will alternate between the measured value and an under-range (Ur) or over-range (Or) indication. When in the auto-ranging mode a range change will occur if the input signal is outside the limits of 27% and 110% of full scale, so that error indications are obtained on the highest and lowest ranges only.

4.11 VOLTAGE PRIMARY MEASUREMENT FUNCTION

- 4.11.1 When first switched on the instrument will be set to the voltage measuring function. If the instrument has been in use and is set for some other measuring function, press

/VOLTS/.

The VOLTS indicator will light.

4.12 POWER PRIMARY MEASUREMENT FUNCTION

- 4.12.1 The 9303 measures in voltage units, but can convert measurements made into power units by squaring the measured voltage and dividing by the resistance value held in the Ω store. To select the power measuring function, press

/WATTS/.

The WATTS indicator will light.

- 4.12.2 The value in the Ω store will be set to 50 Ω on switching on. The number in the store can be displayed by pressing

/RECALL//SHIFT// Ω /.

The RECALL indicator will light when the key is pressed to show that a stored value is being displayed.

- 4.12.3 If no change to the resistance value is required, press

/CONTINUE/.

The RECALL indicator will be extinguished, and the instrument will return to the measurement mode. If the resistance value is to be changed, set the required value on the display, using the numeric keys, followed by

/SHIFT// Ω /.

The RECALL indicator will be extinguished when the first numeric key is pressed. When the required resistance value is set, press

/STORE//SHIFT// Ω /.

The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

4.12.4 At any time up to the point where

/ Ω /

is pressed, the procedure can be aborted by pressing

/CONTINUE/.

The instrument will return to the measurement mode with the resistance value unchanged.

NOTE: The values held in the %, RATIO, NULL and dB stores are in voltage units. The values may have been computed from keyboard inputs or displayed power measurements, using the resistance value in the Ω store at the time of entry. These values are NOT automatically updated when the resistance value in the Ω store is changed.

4.13 RATIO MEASUREMENTS

4.13.1 With the ratio function selected the instrument computes

$$\frac{\text{measured voltage}}{\text{voltage value held in ratio store}}$$

To select the ratio function, press

/RATIO/.

The RATIO indicator will light. Note that the display will indicate a ratio of voltages or powers according to whether the voltage or power measuring function is selected. The conversion to power units uses the current resistance value in the Ω store.

4.13.2 When the instrument is first switched on the RATIO store will be loaded with 1 volt. The value in the store can be displayed by pressing.

/RECALL//RATIO/.

The RECALL indicator will light when the key is pressed to show that a stored value is being displayed. The displayed value will be in voltage or power units, according to the measuring function selected.

- 4.13.3 If no change to the stored level is required press

/CONTINUE/.

The RECALL indicator will be extinguished, and the instrument will return to the measurement mode.

- 4.13.4 If the stored value is to be reset to a specified figure, set the required value on the display using the numeric keys. The RECALL indicator will be extinguished when the first numeric key is pressed. The value set on the display may be in voltage or power units. When the required digits have been set, press

/SHIFT//APPROPRIATE UNITS//STORE//RATIO/.

The appropriate display annunciator will light when the units are entered. The STORE indicator will light when the key is pressed. It will be extinguished, and the instrument will return to the measurement mode, when the storage of the new value is complete.

- 4.13.5 The RATIO store may also be reset to the current displayed value when voltage or power measurements are being made. To reset the stored value to the current displayed value, press

/STORE//RATIO/.

The STORE indicator will light when the key is pressed, and will be extinguished when the storage of the new value is completed.

- 4.13.6 At any time up to the point where

/RATIO/

is pressed either store updating procedure can be aborted by pressing

/CONTINUE/.

4.14 PERCENTAGE DIFFERENCE MEASUREMENTS

- 4.14.1 With the percentage difference function selected the instrument computes

$$\frac{\text{measured voltage} - \text{voltage value in \% store}}{\text{voltage value in \% store}} \times 100$$

To select the percentage difference function, press

/%/.

The % indicator will light. Note that the display will indicate a percentage difference of voltages or powers according to whether the voltage or power measuring function is selected. The conversion to power units uses the current resistance value in the Ω store.